

ISU-FHWA-ACPA Concrete Pavement Surface Characteristics Field Experiments



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TRB ADC40 Mid-year Meeting, 19 July 2005



U.S. Department
of Transportation

**Federal Highway
Administration**





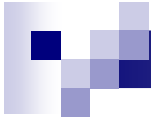
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Presentation

- ISU-FHWA-ACPA program
- Resource leveraging
- 2005 experiments
- Measurement techniques
- Final products and benefits
- Questions and answers

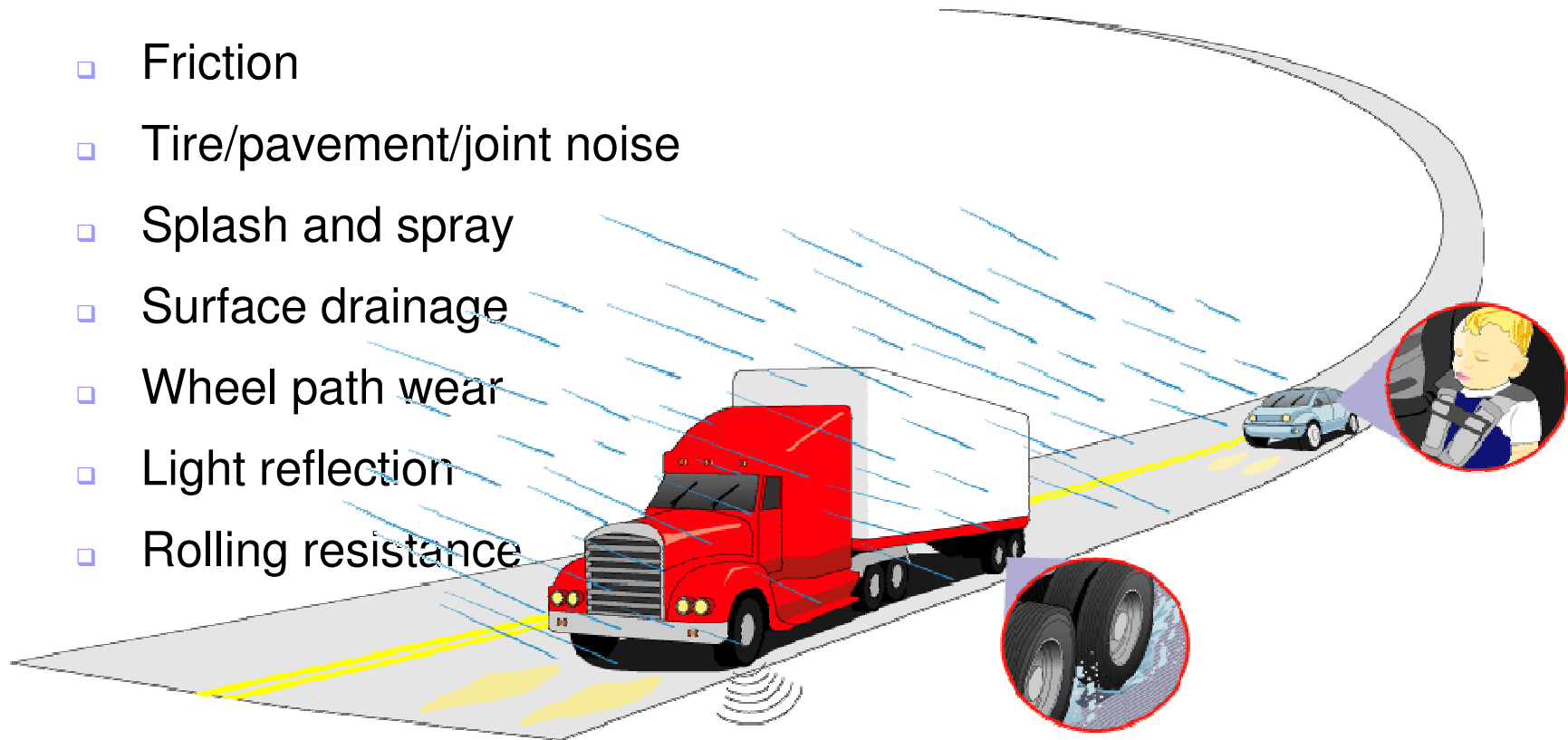


Study Structure

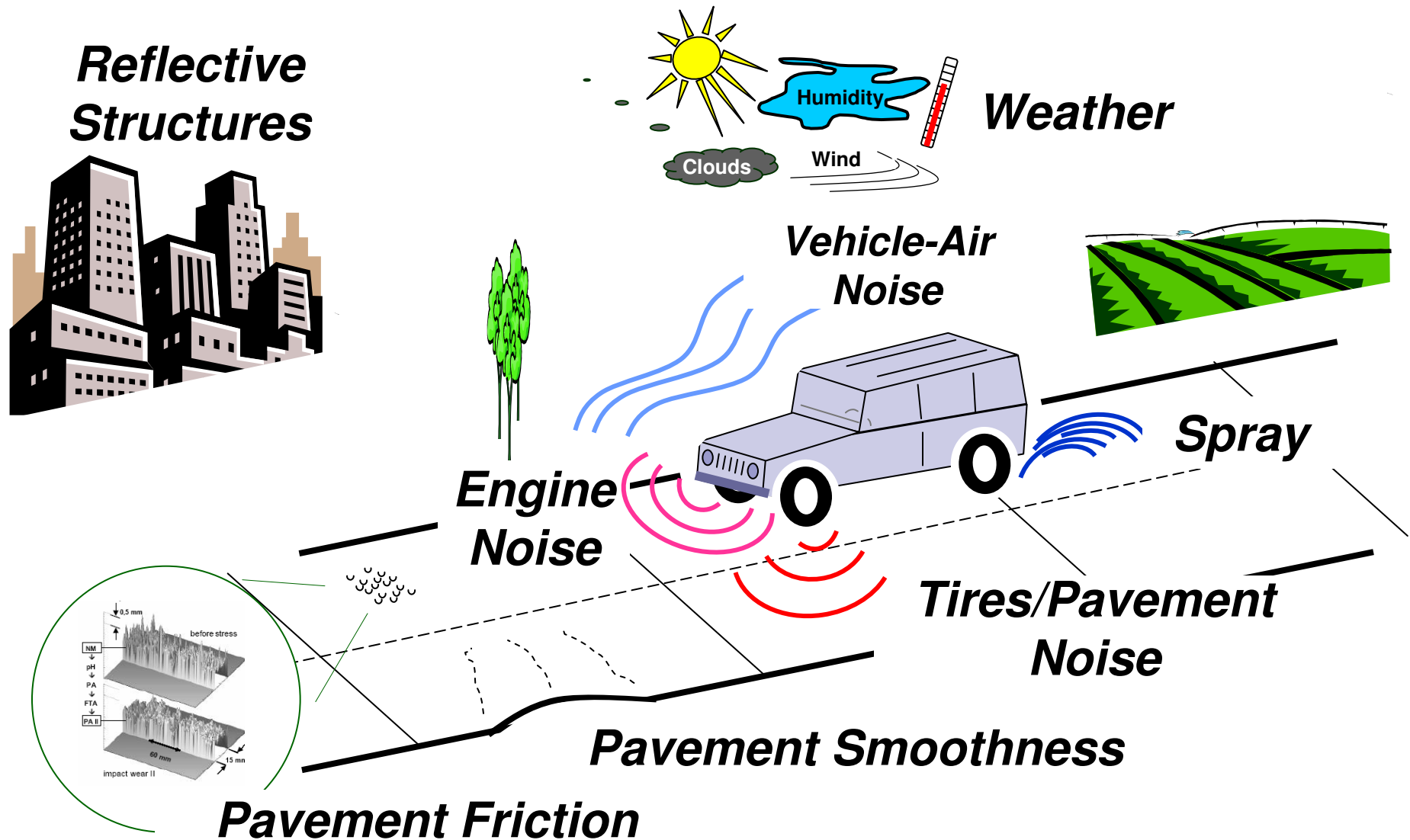
Surface Characteristics

Any factors that effect:

- Smoothness
- Friction
- Tire/pavement/joint noise
- Splash and spray
- Surface drainage
- Wheel path wear
- Light reflection
- Rolling resistance



Noise Measurement Variables





Noise Facts

Fact 1 Worldwide quality of life issue.

Fact 2 Both an urban and rural issue.

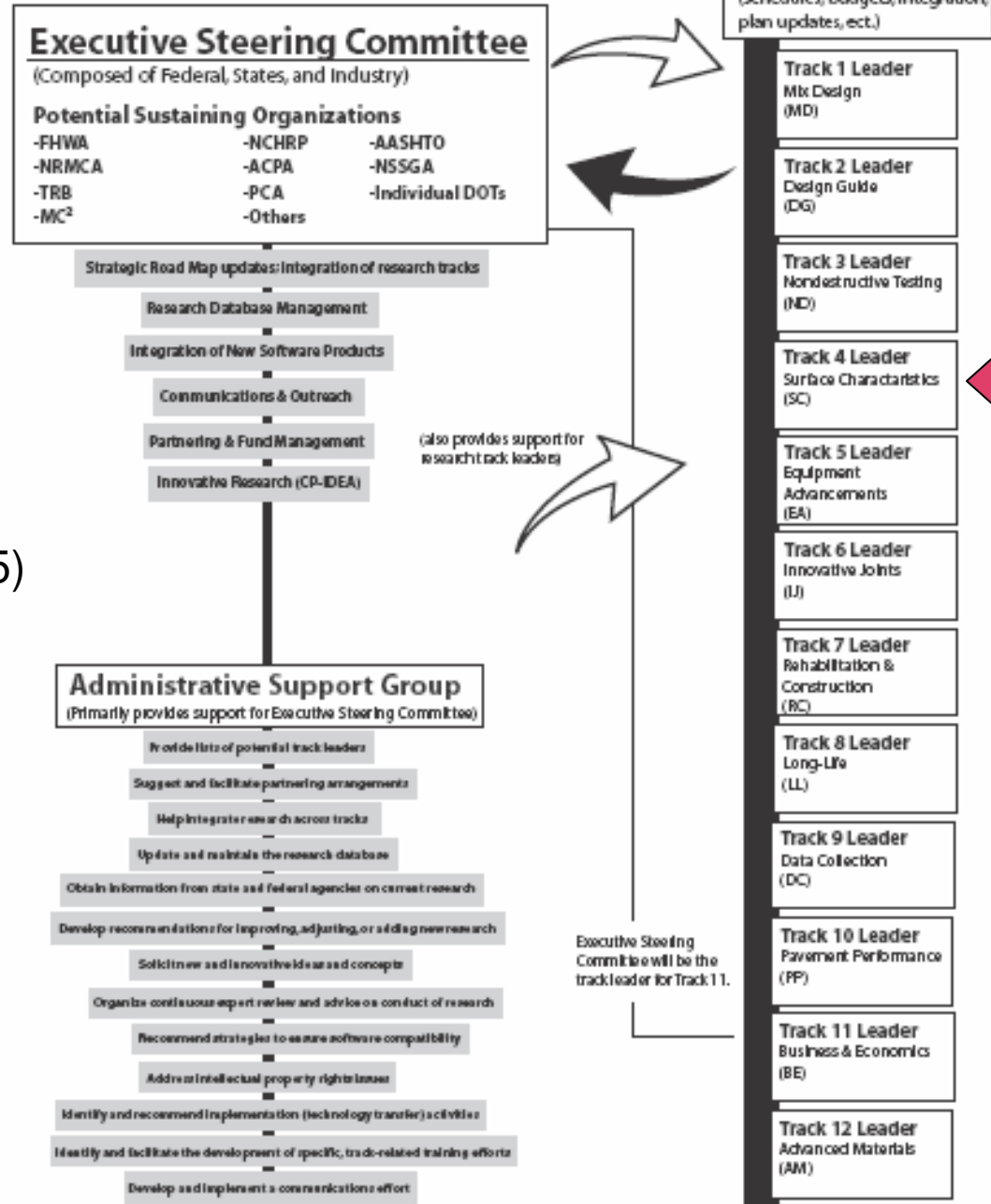
Fact 3 Both a driver and abutter issue.

Fact 4 Competition is driving the issue.

Fact 5 We can solve the problem if we partner!

CP Road Map

Long Term Plan for
Concrete Pavement
Research and
Technology (Task 15)





ISU & FHWA

In June 2004, FHWA and ISU (PCC Center) entered into a cooperative agreement to implement the Concrete Pavement Road Map by:

“Advancing the SC Research Track, with stakeholders, to optimize desirable surface characteristics that includes low noise, high smoothness, acceptable friction and where possible, reduced splash and spray.”



ACPA

In January 2005, ACPA formally joined the FHWA and ISU team to help develop, coordinate, and finance the field experiments program.

The ACPA Chapter-States have joined this endeavor by making noise the number one priority, and serving as local ambassadors.



ISU & FHWA & ACPA

Management raison d'etre

- To implement the Quiet Pavements Scan.
- To leverage funds.
- To leverage experiences.
- To promote teamwork.



ISU & FHWA & ACPA

Technical raison d'etre

- To understand the relationship between noise and texturing/grinding.
- To develop the noise-texture-time relationship.
- To develop construction techniques that are repeatable and cost-effective.



ISU & FHWA & ACPA

Research Gap

Very little systematic information exists to explain the sensitivity of noise to the specific dimensions of each type of texture/grinding, including:

- Directionality; width, depth, and spacing; aggregate properties; mix type; and construction techniques.

Nearly all previous experiments have fallen short due to the lack of noise or texture measurements.



Project Team – ISU

Iowa State University

- Dale Harrington, Tom Cackler, Jim Cable, Jim Grove, Paul Wiegand

TDC Partners, Ltd.

- Ted Ferragut

The Transtec Group, Inc.

- Rob Rasmussen, Eric Mun, Robert Light, Bebe Resendez

Expert Consultants

- Steve Karamihas, Bob Bernhard, Ulf Sandberg

Others



Project Team – FHWA & ACPA

ACPA / IGGA

Jerry Voigt

Larry Scofield

Mike Ayers

John Roberts

Gary Aamold

Terry Kraemer

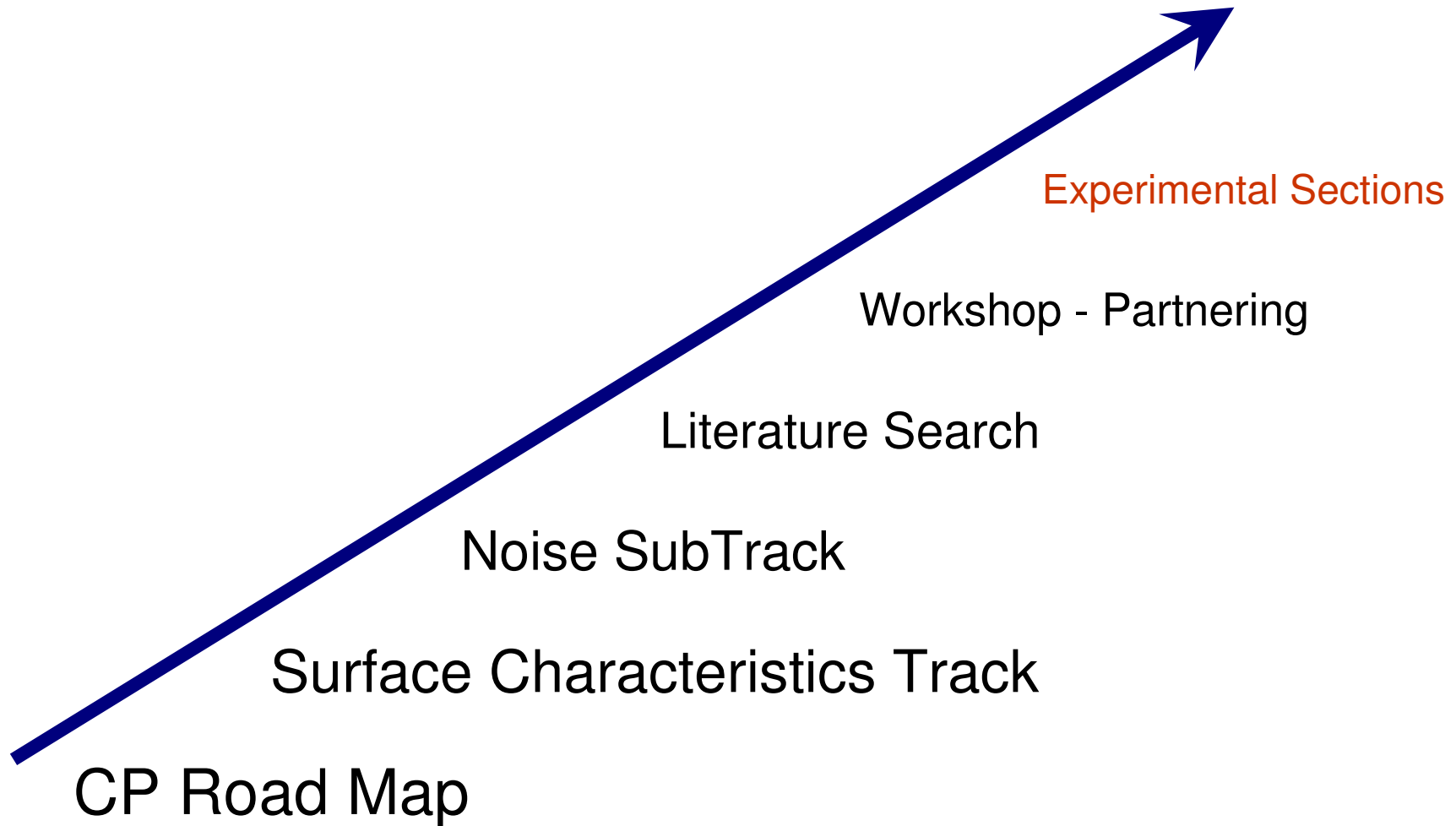
FHWA

Mark Swanlund

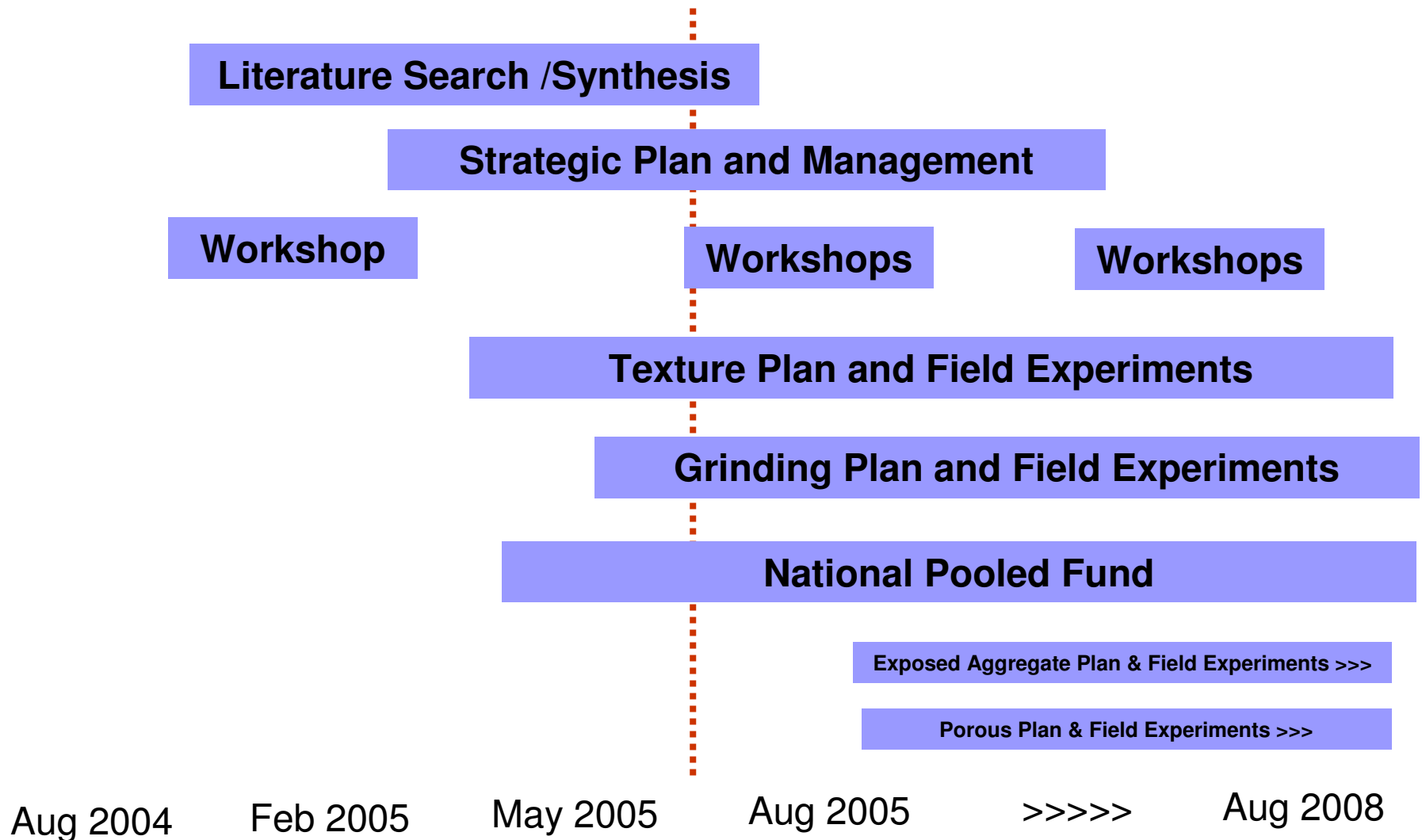
Tom Harman



Action Plan



Noise Program Timeline





Synthesis Report

- Prepare comprehensive documentation on all concrete pavement noise-reduction trials and experiments identified in Strategic Research Track.
 - ☐ Include unpublished results.
 - ☐ Include interviews – telephone and face-to-face.

Note

Draft available from ISU

Seeking comments



November 2004 Workshop

- Validate SC Research Track.
- Understand noise issues.
- Frame comprehensive noise experiments.
- Identify partnering arrangements.

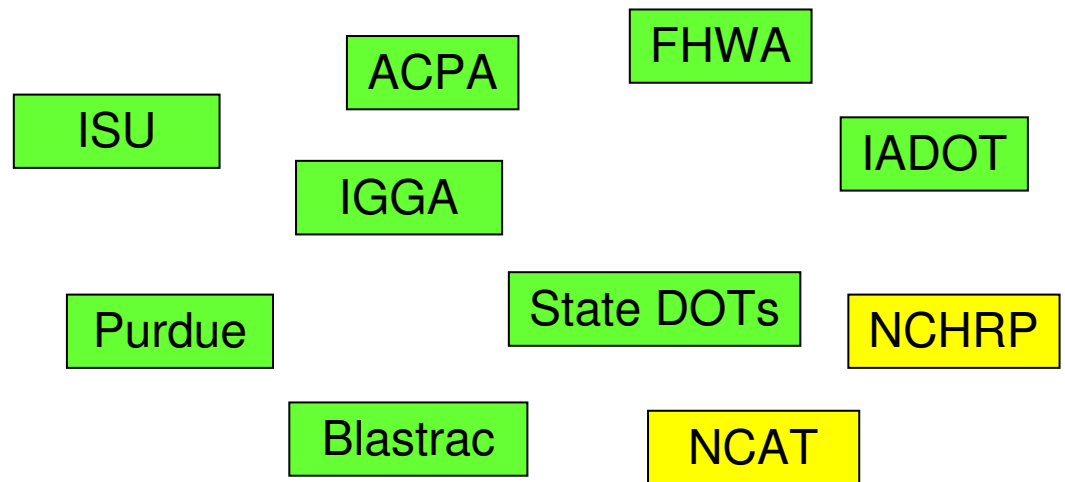
Note

Workshop CD available



Partnering

- Coordinate with key organizations.
- Leverage time and funds.
- *Coordinate measurement systems and techniques.*





Partnering

- FHWA

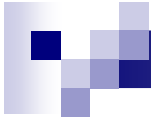
- ☐ Pavement Surface Characteristics Program
- ☐ Smoothness and Noise Expert Task Groups

- NCHRP

- ☐ 10-67: Texturing Concrete Pavements
- ☐ 1-43: Friction Guide
- ☐ 1-44: Measuring Tire/Pavement Noise at Source
- ☐ 8-56: Truck Noise Source Mapping

- NCAT

- ☐ Noise measurement and analysis techniques



Field Experiments



Field Experiments

A performance-based noise specification:

- *The tire-pavement noise shall not exceed **X dB(A)** or contain tonal “spikes” at **Y Hz** for **P1%** of the pavement when measured by **Z procedure** at **D days** after placement.*
- *Furthermore, the noise shall not exceed these values for **P2%** of the pavement after a **T year** period.*

Note

This isn't being promoted !!!

But, are we prepared to fill in the missing details?



Field Experiments

- Key Study Points

1. Study all types of textures.
2. Study noise versus texture.
3. Relative ranking, not elimination.
4. Sophisticated modeling not viable at this time.
5. Control construction variability without heavy capital expenditure.



Plan Details

- *Task 0. Funding Plan and Framework*
- Task 1. Experimental Plan Details
- Task 2. Identify Sites (Type 1, 2, and 3)
- Task 3. Develop Data Collection / QC Plans
- Task 4. Coordinate with DOTs
- Task 5. Construction and Field Testing
- Task 6. Analyze and Report



Study Types

- Type 1. New Construction

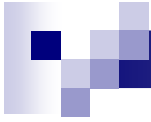
- ☐ Measure noise, texture, smoothness, friction, and concrete early, frequently, detailed, and simultaneously.
 - Identify interrelationships
 - Determine rate of change
 - Determine construction variability

- Type 2. In Service

- ☐ Measure noise, texture, smoothness, friction periodically.

- Type 3. In Service

- ☐ Measure noise and texture, one time only.



Type 1 – Conventional Texturing

Construction

- Up to 10 texture configurations
- Longitudinal & transverse tining, broom, and turf
- Width and depth variations
- One 6000 foot site
- 600 ft. test sections
- All pending exact site selection
- Texturing best practices

Purpose: constructability and early time history




Type 1 – Conventional Texturing

- ± 3 transverse, uniform, random
 - Spacing: 0.5", 1", random
 - 1 depth @ 0.125"
- ± 5 longitudinal, uniform
 - Spacing: 0.5", 0.75", 1"
 - 2 depths for 0.75" – 0.125" and 0.250"
- ± 2 drag textures: 1 burlap and 1 turf
- Combinations of drag and tining

Note

Experimental design will be customized for specific site, learning from one and adapting to next.



Type 1 – Grinding

- New Grinding, Evaluate Annually

- ☐ Multiple configurations
- ☐ Hard and soft aggregates
- ☐ Vary blade spacing
- ☐ Vary blade depth

Note

Experimental design currently being framed.

Note

Check results at Purdue SQDH.



Type 2 – Texturing/Grinding

- In Service, Evaluate Annually

- ☐ Relatively new (one year or less)
- ☐ Loud and quiet sites
- ☐ Variety of configurations – width and depth variations
- ☐ Ideally 2500' – Noise, texture, friction, smoothness
- ☐ Purpose: constructability, variability, time history

Note

Project
identification
underway.



Type 3 – Texturing/Grinding

- In Service, One Time Only

- ☐ Any age
- ☐ Loud and quiet sites
- ☐ Variety of configurations – width and depth variations
- ☐ Noise & texture, one time
- ☐ Purpose: inventory and noise-texture relationships

Note

Project identification underway.

Texture measures will depend on traffic closure.



Estimated Number of Sites

	Texturing	Grinding
Type 1 New	2	2
Type 2 Existing	8	
Type 3 Existing	24	



Total Funding

Federal Highway Administration	\$211,000
Iowa State University PCC Center Federal Allocation	\$150,000
American Concrete Pavement Association	\$261,000
Iowa Highway Research Board	\$ 96,700
TOTAL	\$718,700
Other Funding Sources	\$281,300
GRAND TOTAL	\$1,000,000



DOT Assistance

Type 1 and 2

DOT Coordination

Materials Support

Construction Support (Type 1)

Traffic Control

Friction (Skid) Trailer

Type 3

DOT Coordination

Traffic Control



2006 Experiments

- Texturing (cont.)
- Grinding (cont.)

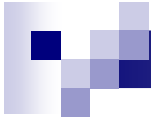
Note

Pooled fund mechanism

- Porous Concrete
- Exposed Aggregate
- Other

Note

Plans will be developed later this summer.



Measurements



Measurements

- Simultaneous collection of mega-, macro-, and micro-texture.
- Noise, smoothness, friction, and concrete tests.
- Demonstration of innovative equipment.
- Early, frequent, and detailed data collection:
 - First days of operation.
 - 30 to 90 days later.
 - Yearly until stable.



Measurements

Noise

- ❑ On-Board Sound Intensity (OBSI)
- ❑ Pass-by (PB)
- ❑ In-Vehicle

Smoothness

- ❑ Inertial Profiler

Macrotexture

- ❑ RoboTex (line laser)
- ❑ Circular Texture Meter (CTM)
- ❑ Digital imaging
- ❑ Sand patch

Microtexture / Friction

- ❑ Dynamic Friction Tester (DFT)
- ❑ Locked wheel skid trailer (smooth tire)

Noise Protocols

On-Board Sound Intensity (OBSI)

- ❑ Developed by Dr. Paul Donovan and General Motors
- ❑ Routinely used by Caltrans, Arizona DOT, and FHWA (R&D)
- ❑ Used in NITE Study to compare Euro to US Practice
- ❑ Hundreds of pavement sections already evaluated
- ❑ Standardization from NCHRP 1-44 or AASHTO SOM likely
- ❑ Standardization as ISO 11819-2 Annex or new ISO 11819-3 possible



Noise Protocols

On-Board Sound Intensity (OBSI)

- ❑ SI differs from CPX “noise trailer” which measures Sound Pressure
- ❑ Paired microphones in SI allow for directionalized measurement
- ❑ Shielding from external noise sources not required



Noise Protocols

Pass-by (PB)

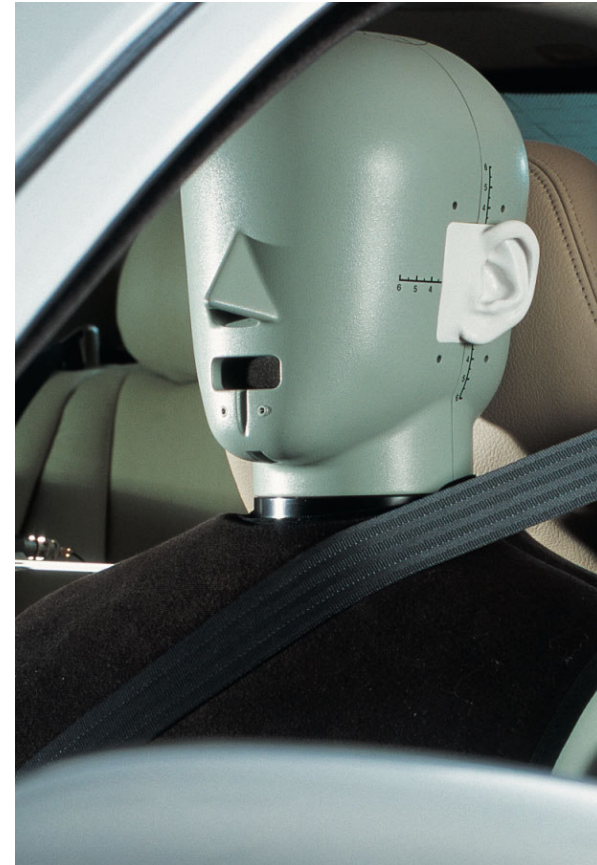
- ❑ Statistical pass-by (SPB) currently used in FHWA Policy
- ❑ Controlled pass-by (CPB) is recommended for this project
- ❑ SPB standardized by ISO (11819-1) and FHWA
- ❑ CPB follows same measurement standards but with fixed vehicle
- ❑ Same vehicle should be used for OBSI and CPB



Noise Protocols

In-Vehicle Noise

- Standardized by SAE J1477 and ISO 5128
- Same vehicle should be used for OBSI and In-Vehicle noise



Smoothness Protocols

Inertial Profiler

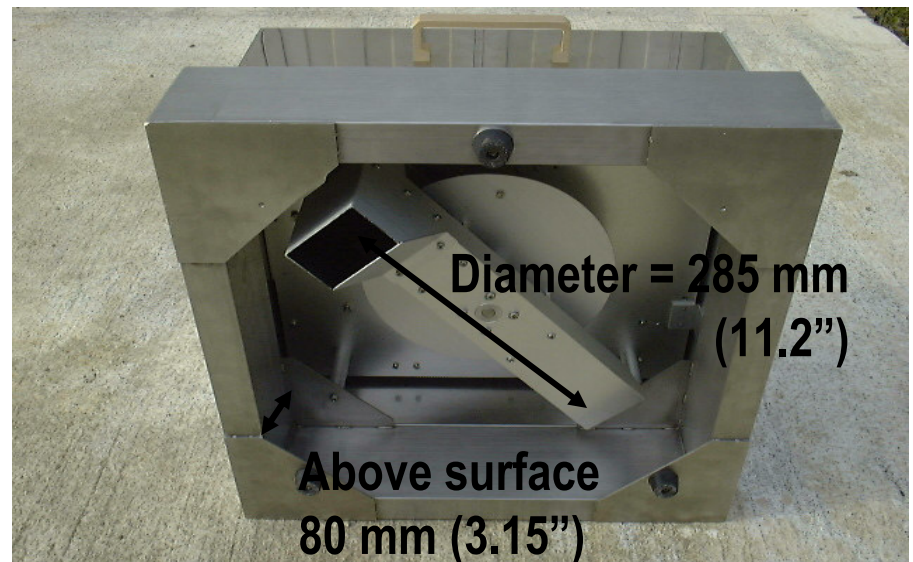
- ❑ Ideal profiler with small recording interval, < 10 mm
- ❑ Use standard operating procedures with enhanced QC
- ❑ Strict protocols for test location delineation (event marking)
- ❑ Strict protocols for test speed and lateral positioning
- ❑ Repeat runs – 10 runs or more, or until repeatability tests are satisfied



Macrotexture Protocols

Circular Texture Meter (CTM)

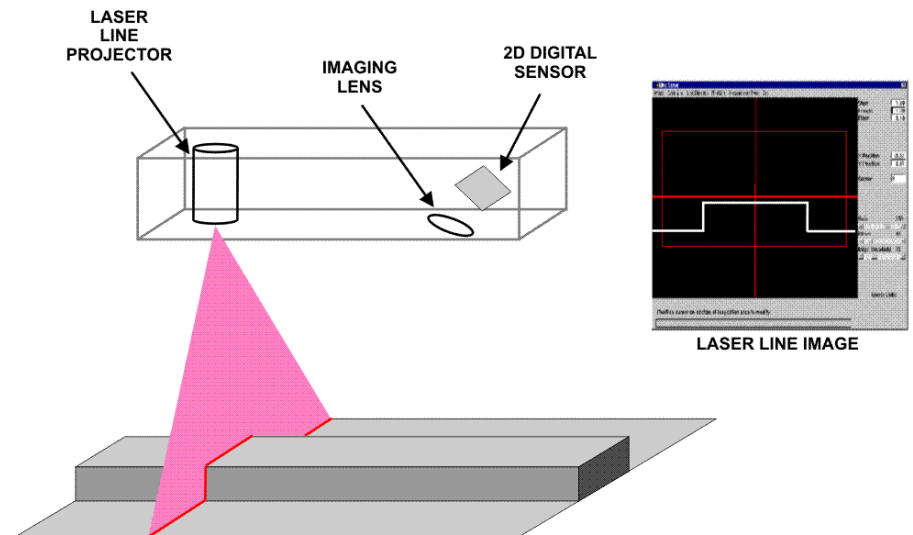
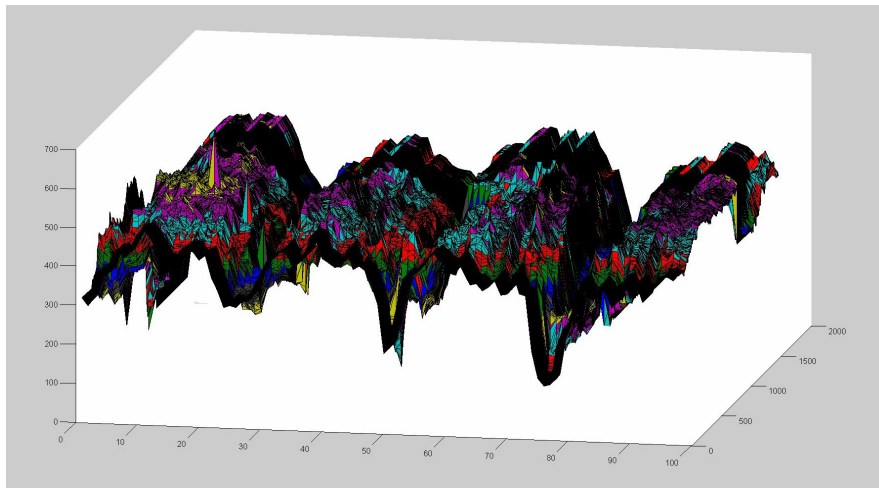
- ❑ Stationary test using laser height sensor
- ❑ Evaluates texture profile by circular sample (samples all directions)
- ❑ Standardized in ASTM E 2157
- ❑ Currently used by Arizona DOT, Virginia DOT, others
- ❑ Equipment Manufactured in Japan
- ❑ Directional texture difficult to interpret



Macrotexture Protocols

RoboTex Texture Device

- ❑ Robotic Texture Device built around LMI Selcom line laser
- ❑ 3D texture profiling at 1 mm × 1 mm sample interval
- ❑ Same line laser unit currently being evaluated by profiler vendors



RoboTex Texture Device



RoboTex Texture Device

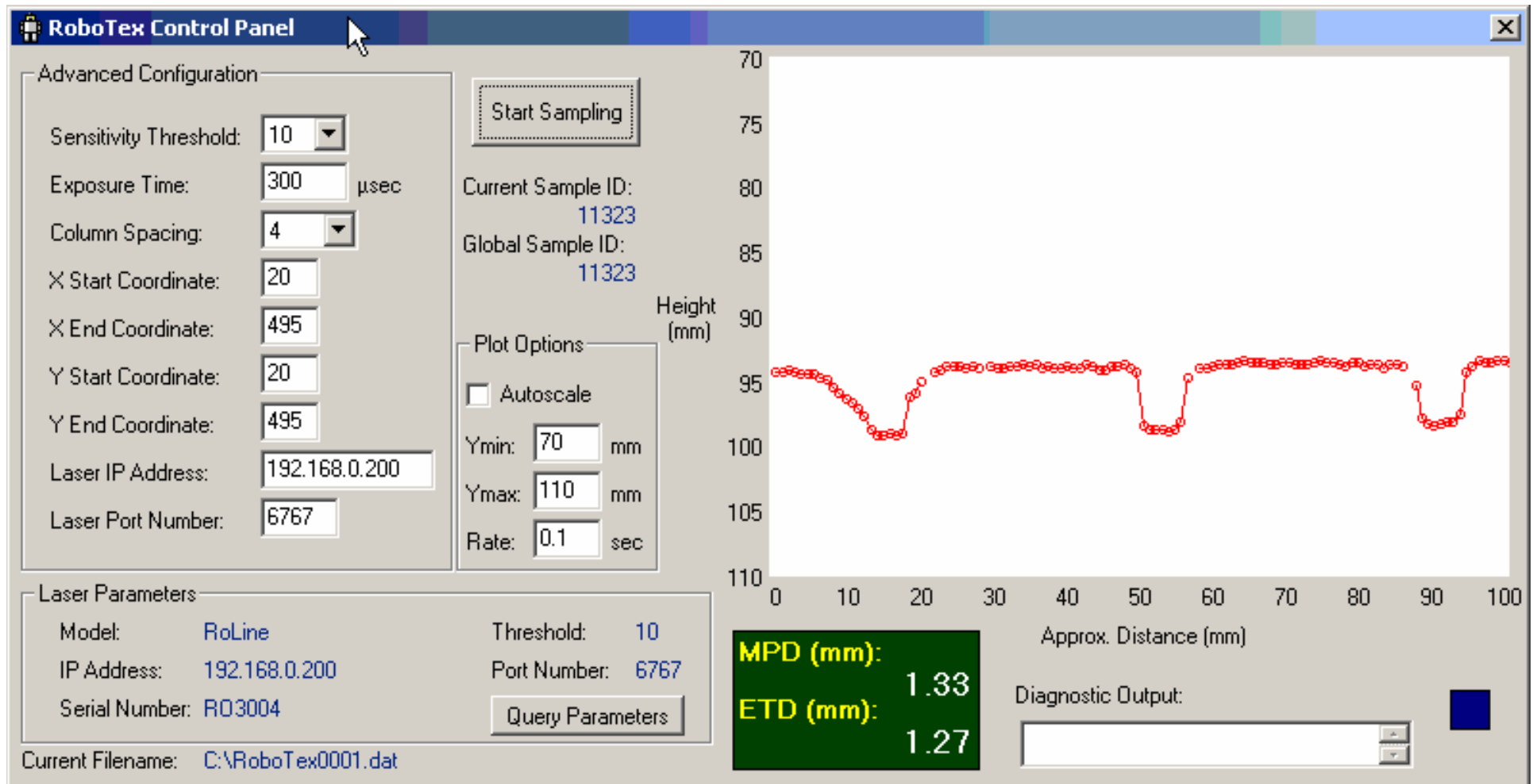




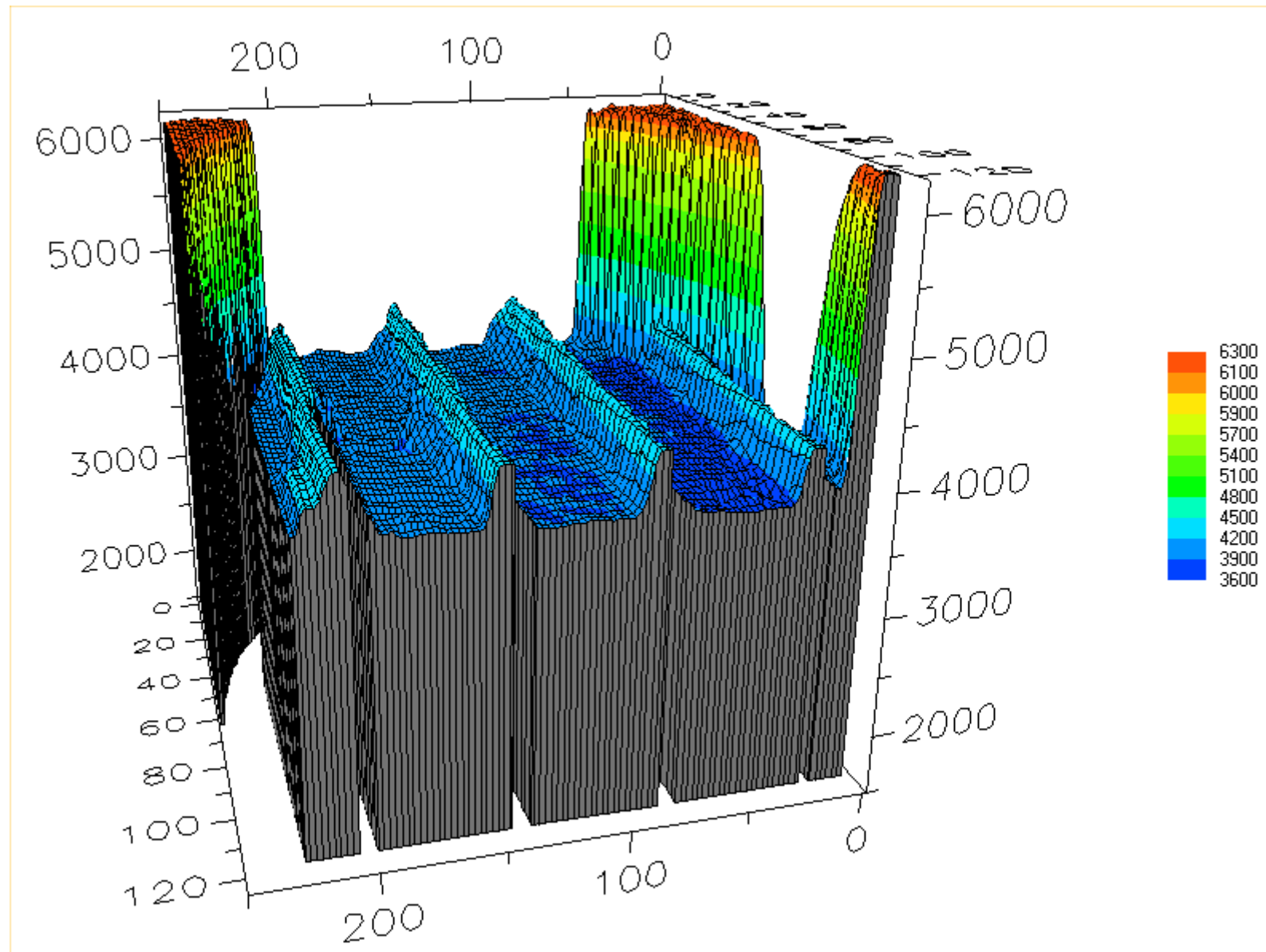
RoboTex Texture Device



RoboTex Texture Device



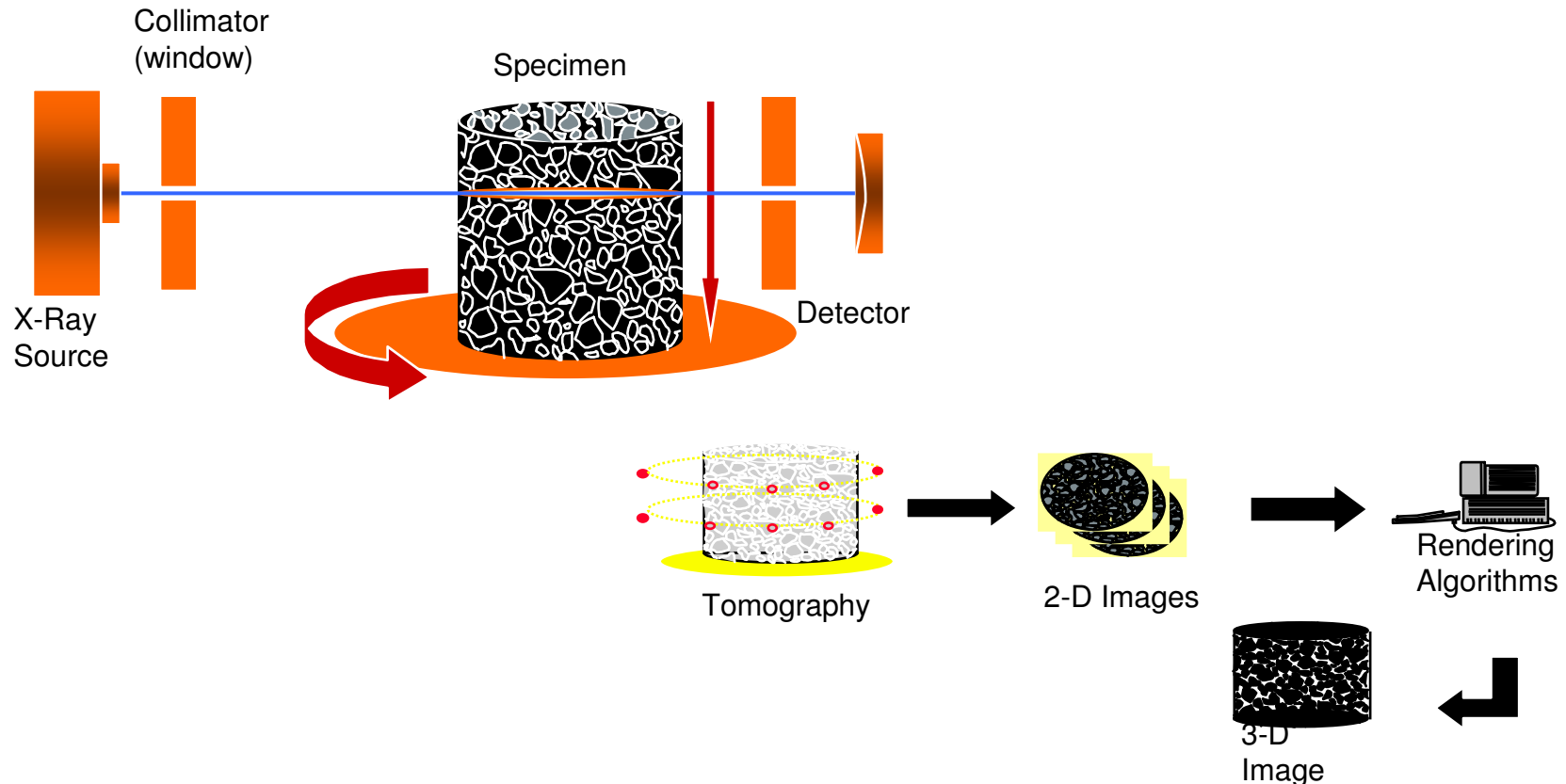
RoboTex Texture Device



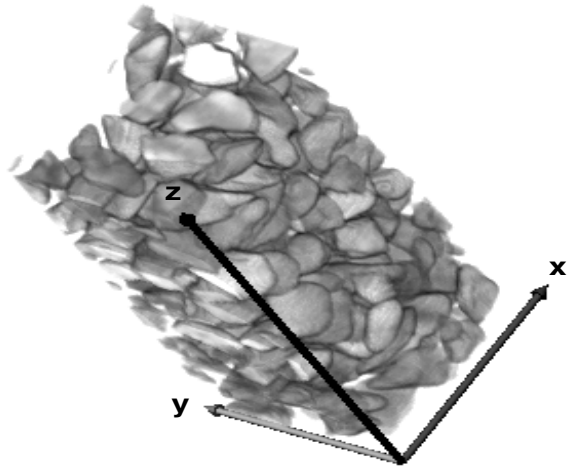
Macrotexture Protocols

Image Analysis Techniques

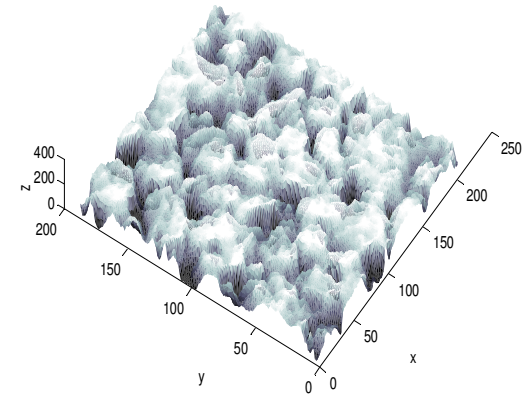
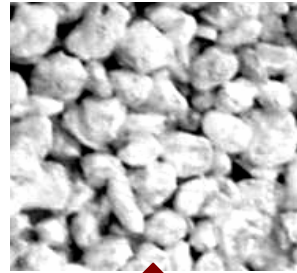
- X-Ray Computed Tomography
- Unabsorbed X-rays lead to 2D Images, processed to 3D Images



Macrotexture Protocols



3D Representation
Aggregate Structure X-ray
CT images

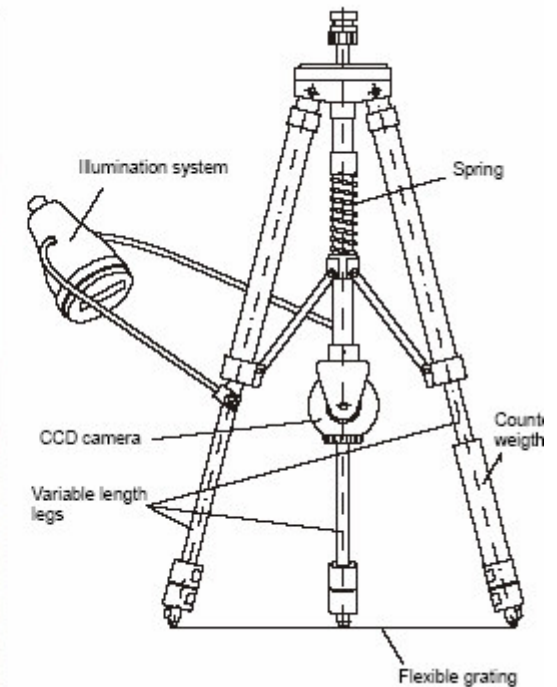
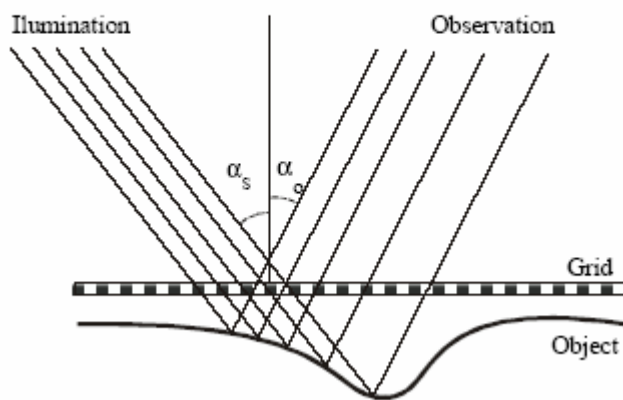
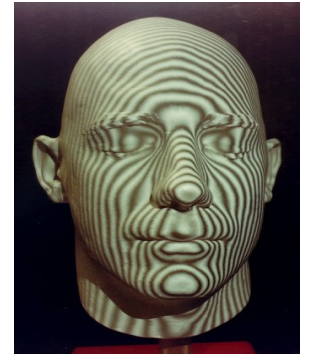


Surface plot of a porous PCC pavement.

Macrotexture Protocols

Digital Imaging

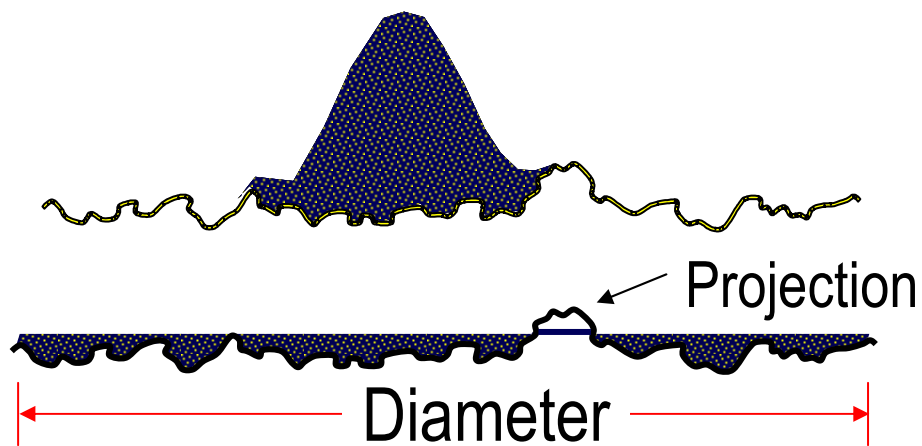
- Photography with varied focal lengths
- Moiré Interferometry
- Stereography
- Post processing can be conducted by FHWA at Turner-Fairbank HRC



Macrotexture Protocols

Sand Patch

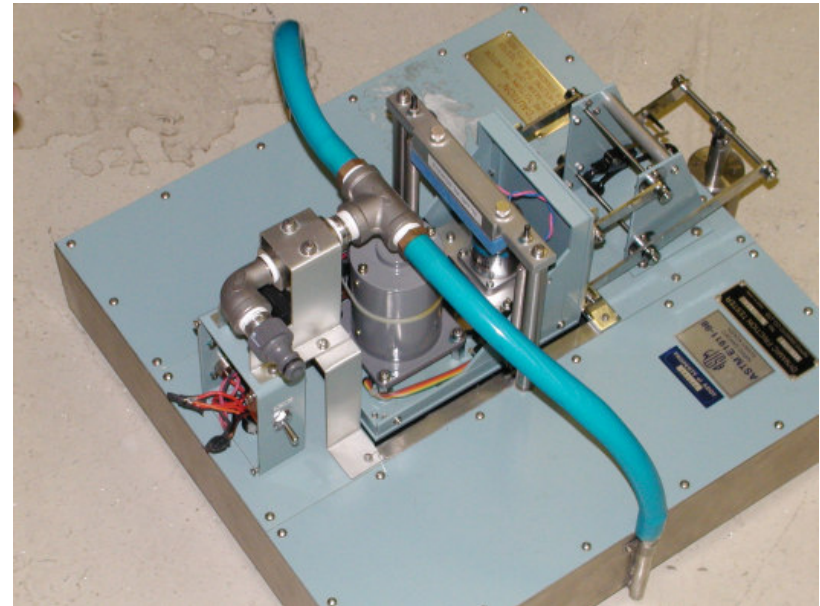
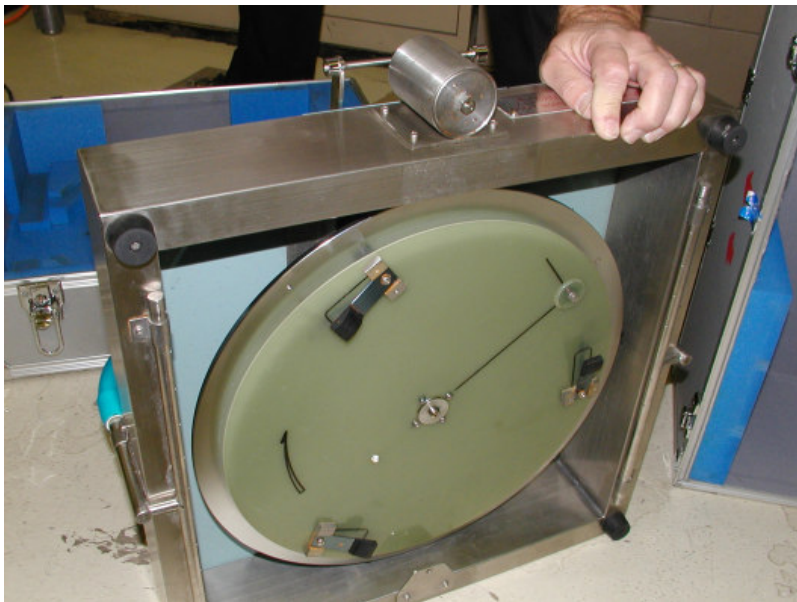
- Known volume of sand (or glass beads) is spread in a circular pattern on the pavement surface. The area of the circle is measured, and texture depth calculated
- Measures Mean Texture Depth (MTD)
- Standardized in ASTM E 965
- While of little value to advanced analyses – important for historical continuity and to gauge existing texture specifications



Microtexture / Friction Protocols

Dynamic Friction Tester

- ❑ Measures friction as a function of slip speed
- ❑ Measures wet friction on small rubber pads which slow from 50 mph to stop
- ❑ Coupled with macrotexture, allows prediction of International Friction Index (IFI)
- ❑ Standardized in ASTM E 1911

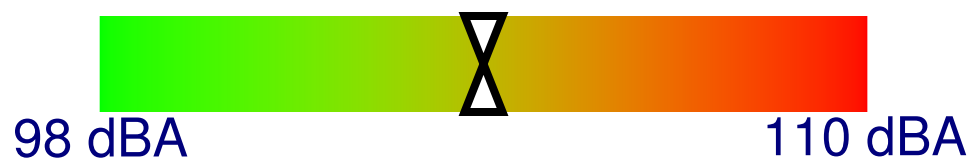


Microtexture / Friction Protocols

Locked Wheel Skid Trailer (with Smooth Tire)

- ❑ Measures wet friction at one slip speed = velocity of test vehicle
- ❑ Smooth tire allows for differentiation of macrotexture effects on friction
- ❑ Allows for comparison to DOT current practices
- ❑ Standardized in ASTM E 274 (ASTM E 524 for test tire)





104.0 dBA

Caltrans LA-138 (N014) – 30mm Dense Graded



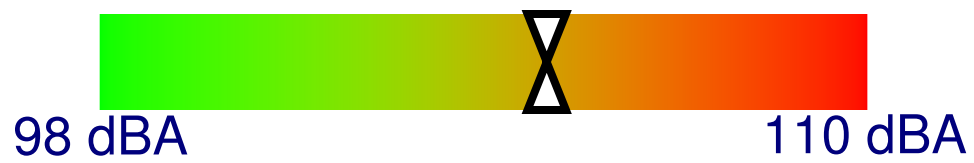
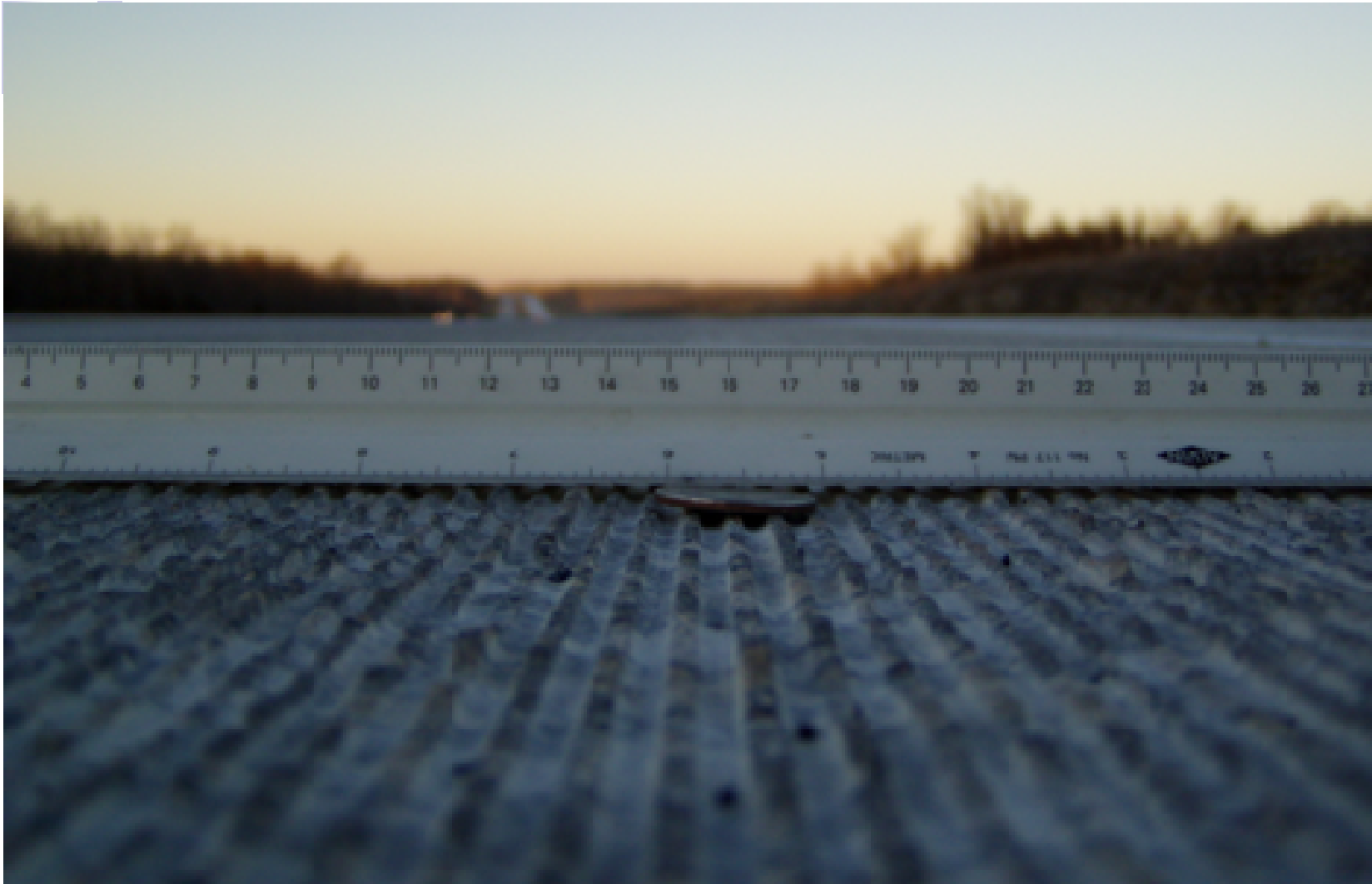
98.7 dBA

Caltrans LA-138 (N014) – 75mm Open Graded



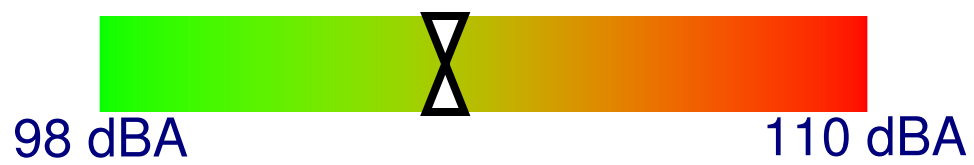
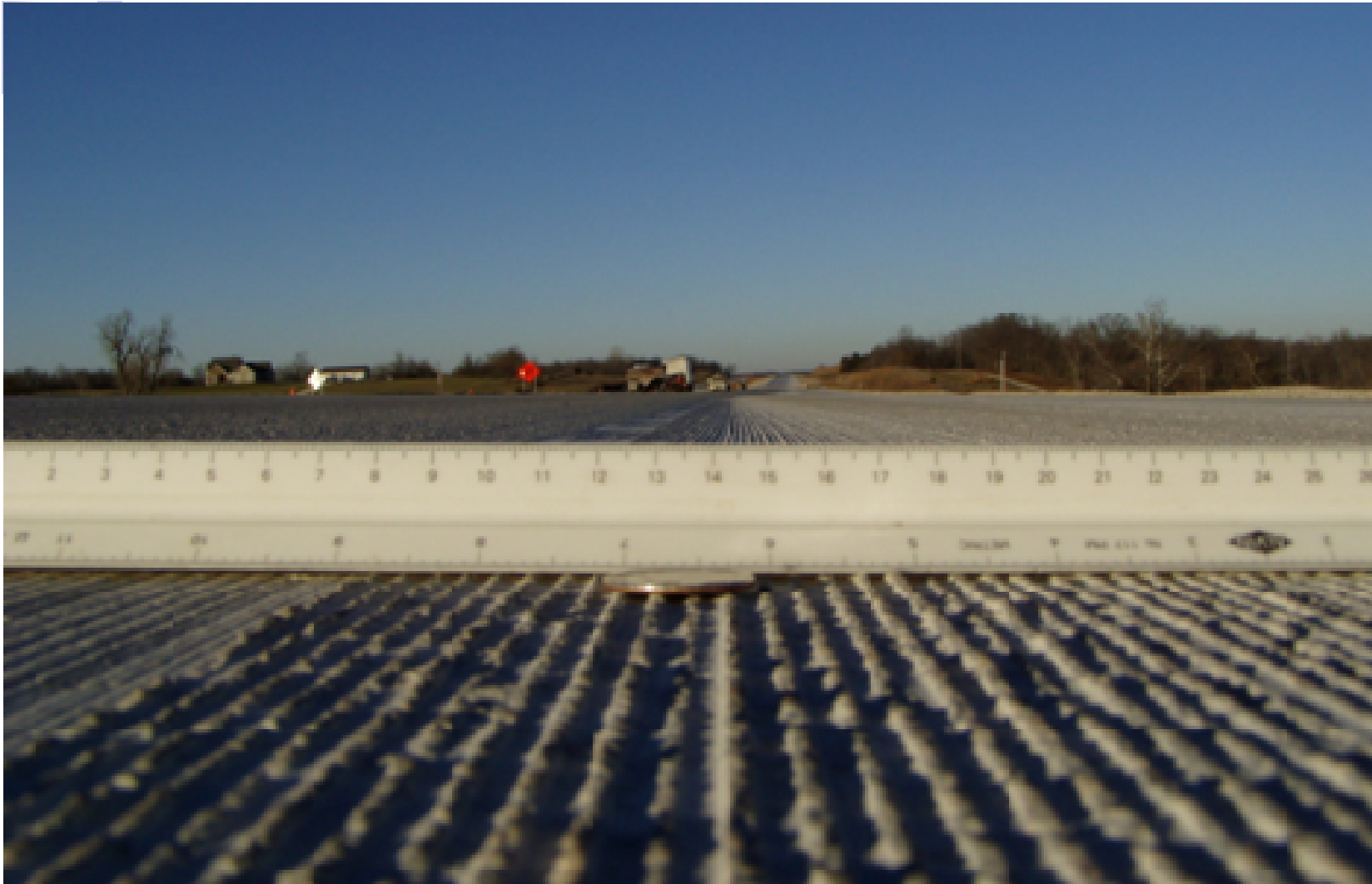
109.4 dBA

PA DOT I-81 (N022) – Transverse Tining (Shoulder)



105.0 dBA

KS DOT US 69 (N023) – Ground 130 No Jacks



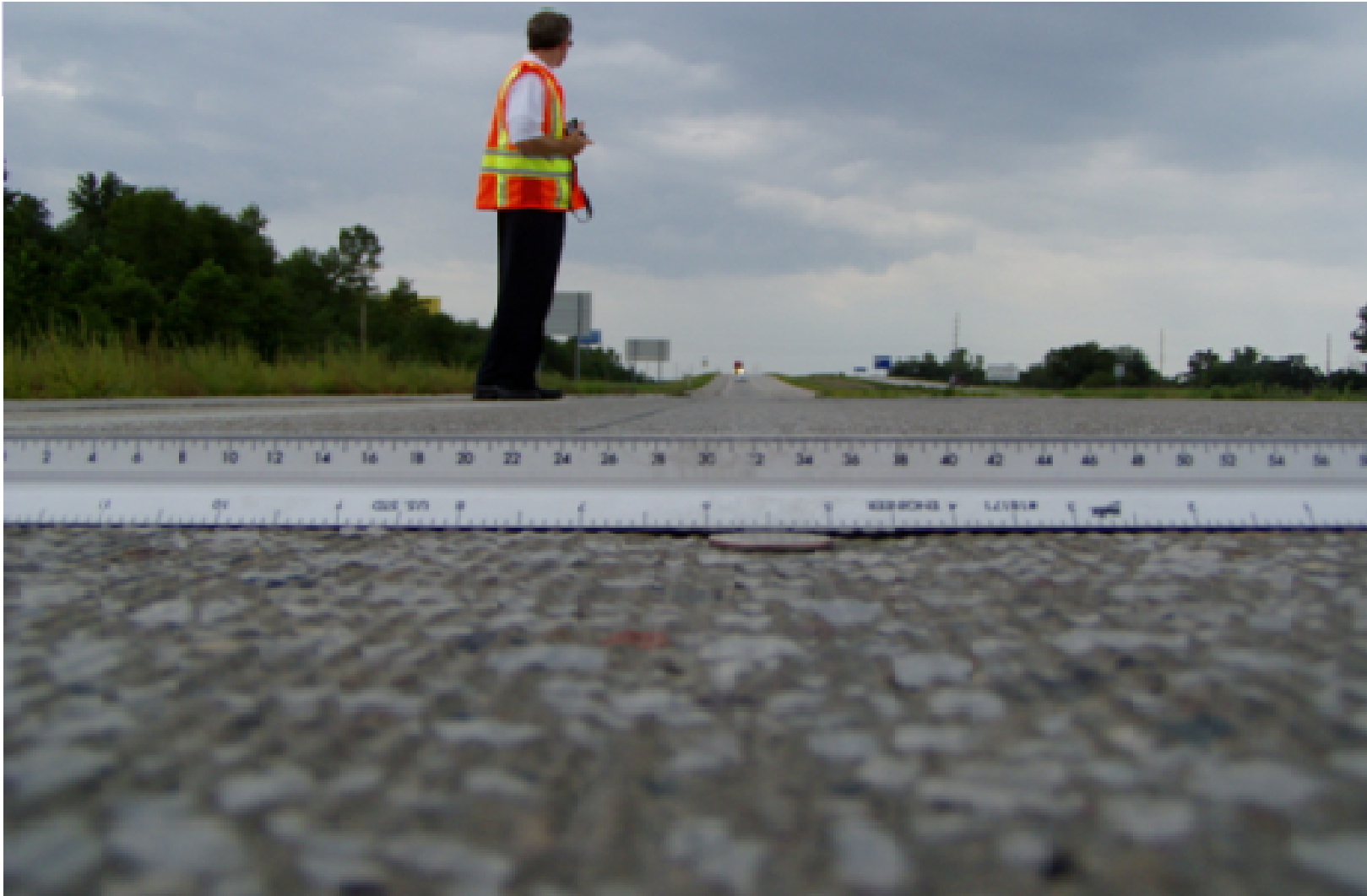
103.4 dBA

KS DOT US 69 (N023) – Ground 120 No Jacks



102.6 dBA

KS DOT US 69 (N023) – Ground 110 No Jacks



100.9 dBA

MO DOT US 71 (N021) – Diamond Ground



Construction Control



Construction Control

- A performance-based noise specification:
 - *The tire-pavement noise shall not exceed **X dB(A)** or contain tonal “spikes” at **Y Hz** for **P1%** of the pavement when measured by **Z procedure** at **D days** after placement.*
 - *Furthermore, the noise shall not exceed these values for **P2%** of the pavement after a **T year** period.*



Construction Control

Same old construction techniques
will get us
the same old values.

WE NEED A HIGHER ORDER
CONSTRUCTION CONTROL!!



Construction Control

- Demonstrate how texture variability affects noise, friction, and possibly smoothness.
- Demonstrate the ability of specific construction methods to control texture variability.



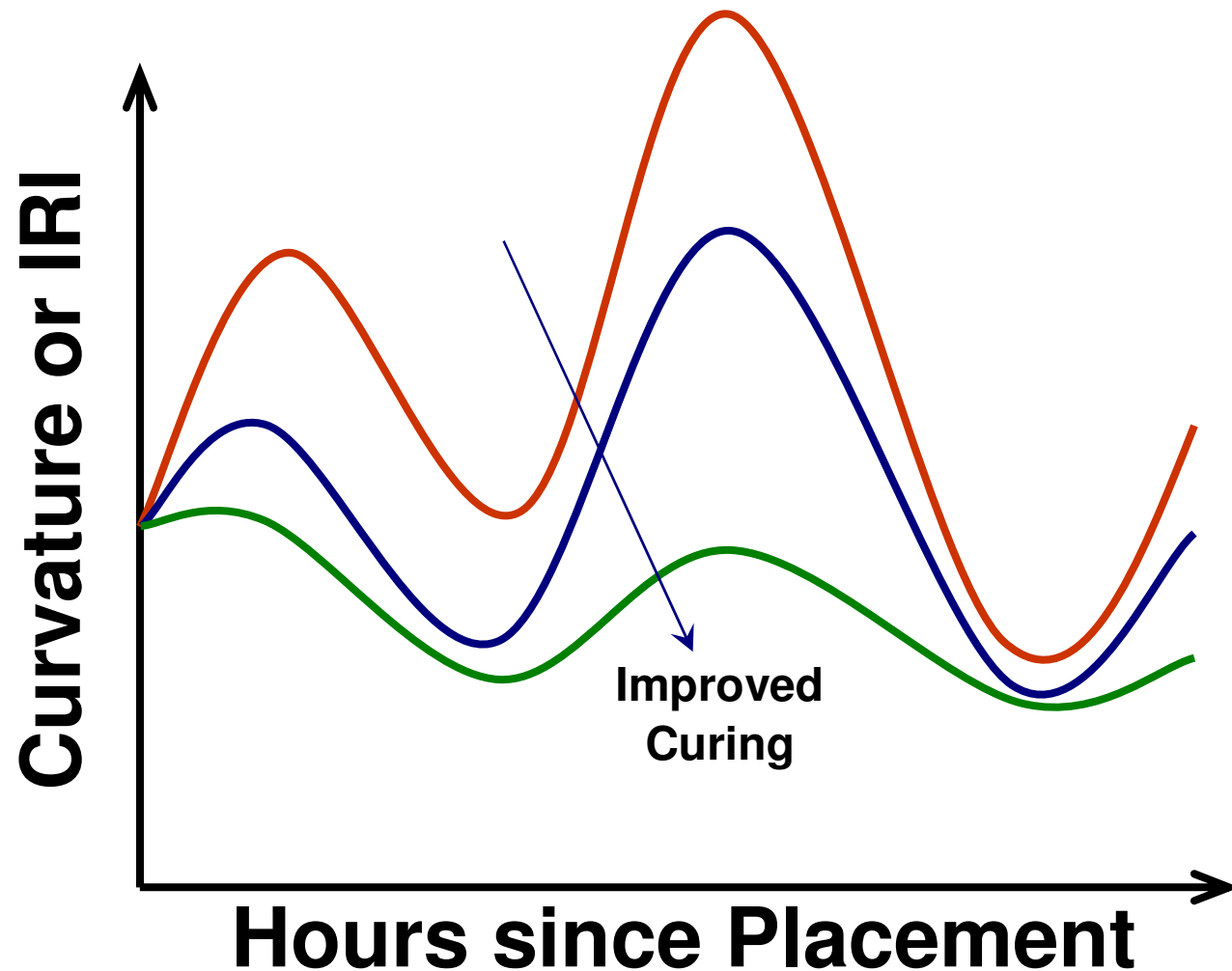
Measurements – Zero Time

- Zero time is when changes in a SC begin
- For smoothness, this is time of construction
- For texture, friction, noise, this is time of opening to traffic

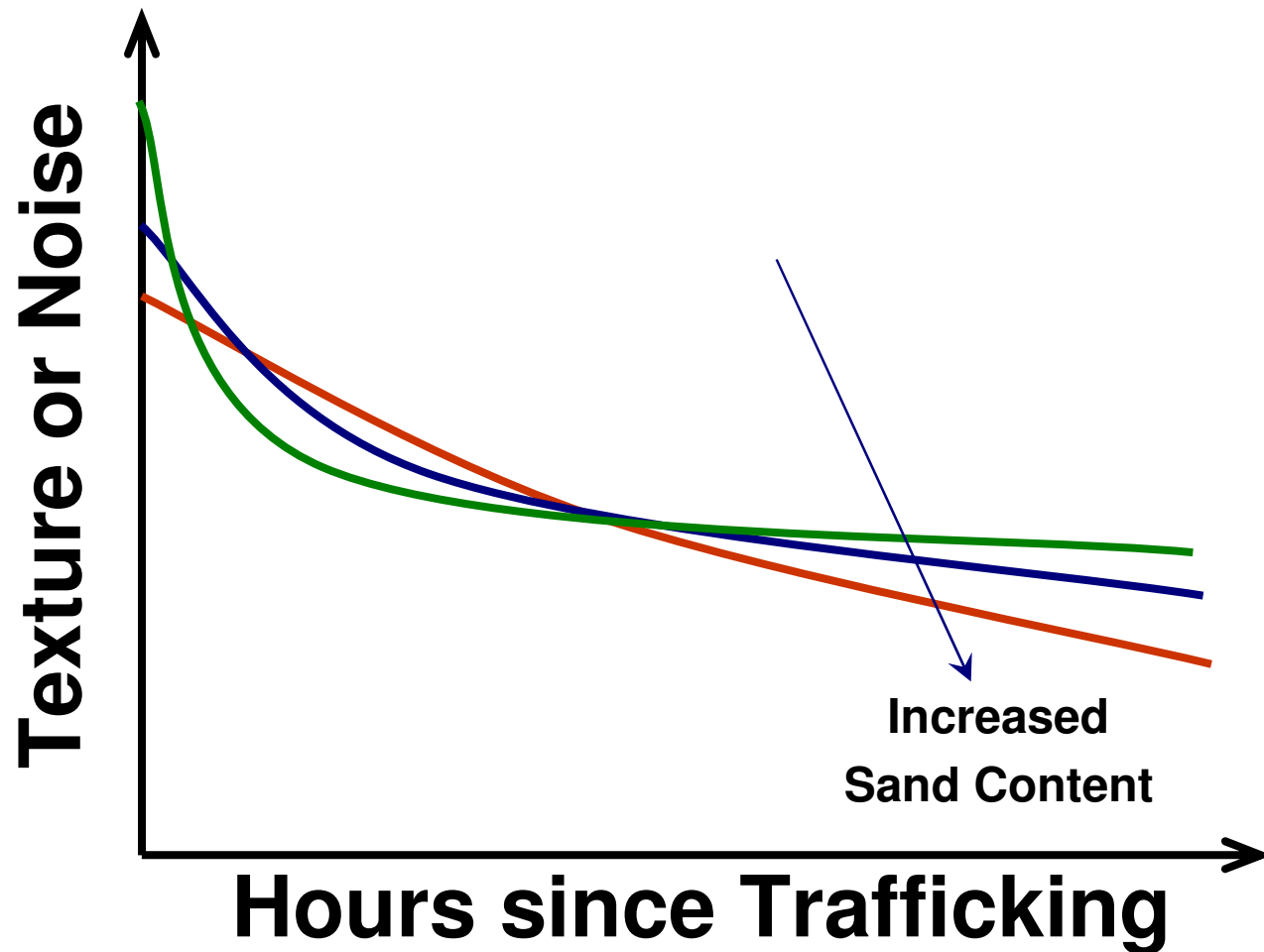
Note

These are first thoughts.

Measurements – Zero Time



Measurements – Zero Time





Closing



Study Benefits

- Leveraged funds.
- National coordination of SC activities.
- Early data. Quality data. Public data.
- Consistent measurements.
- Industry participation and openness.



Expected Findings

- Understand noise vis-à-vis texture over time.
- Categorize / rank various configurations.
- Understand variability.
- Understand tradeoffs – noise-friction-smoothness.
- Improved construction practices.
- Apply site specific solutions, if necessary.



Thank You

For more information, please contact:

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